Environment Canada Environnement Canada

Canada

SURVEY OF TOXIC ORGANIC CONSTITUENTS IN THE ATLANTIC REGION'S AQUATIC ENVIRONMENT (1979-81)

IWD-AR-WQB-83-48

INLAND WATERS DIRECTORATE
ATLANTIC REGION
WATER QUALITY BRANCH
MONCTON, NEW BRUNSWICK

SURVEY OF TOXIC ORGANIC CONSTITUENTS

IN THE ATLANTIC REGION'S

AQUATIC ENVIRONMENT (1979/81)

IWD-AR-WQB-83-48

INLAND WATERS DIRECTORATE

ENVIRONMENT CANADA

Harold S. Bailey

Geoff D. Howell

Water Quality Branch

Atlantic Region

Moncton, N. B.

October 19, 1983

IWD Atlantic Report Series

This report is one of several that are published each year by Inland Waters Directorate, Atlantic Region (Environment Canada). In order to ensure that these reports are available to interested readers in either official language, it is first necessary to determine the language preference of our readers.

Accordingly, it would be helpful if people who read this report would complete the tear-off portion of this page and return it to the indicated address.

Rapports de la Direction générale des eaux intérieures, Région de l'Atlantique

Le rapport que vous trouverez ci-joint est l'un de ceux que publie chaque année la Direction générale des eaux intérieures, Région de l'Atlantique (Environnement Canada). Afin de nous assurer que les personnes qui s'intéressent à ces rapports pourront les lire dans la langue officielle de leur choix, nous avons décidé de mener une petite enquête auprès d'elles.

Vous nous obligeriez donc en remplissant la partie détachable qui se trouve au bas de la présente page et en la retournant a l'adresse indiquée.

IWD-AR-WQB-83-48

Return to:

Regional Director, Atlantic
Inland Waters Directorate
Environment Canada
5th Floor, Queen Square
45 Alderney Drive
Dartmouth, N. S.
B2Y 2N6

Prière de retourner au:

Directeur régional, Atlantique
Direction générale des eaux intérieures
Environnement Canada
5e étage, Queen Square
45, promenade Alderney
Dartmouth (N.-E.)
B2Y 2N6

1. I am interested in receiving future copies of reports in this series. Yes _____ No _____

   J'aimerais recevoir les prochains rapports publiés par la Direction générale des eaux intérieures. Oui _____ Non _____

2. I would like to receive future reports in: English _____ French _____

   J'aimerais que les rapports qui me serong envoyés soient: en englais _____ en français _____

Name and Address:
Nom et address: _____

_____

_____

_____

LETTER OF TRANSMITTAL

Water Quality Branch
Inland Waters Directorate
Environment Canada
P. O. Box 861
Moncton, N. B.
October 19, 1983

Mr. R. Côté, Chairman
Regional Toxic Chemicals Committee
45 Alderney Drive
Dartmouth, N. S.
B2Y 2N6

Dear Mr. Côté:

During the three year period, 1979-81, the Water Quality Branch collected and analysed water and/or sediment samples from eighty-four sites in the Atlantic Region, for selected Toxic Chemicals. The purpose being to characterize and measure the distribution of these chemicals as an input to the Environment Conservation Service role in the Toxic Chemical Program.

It is expected that the findings as contained in this report entitled, "Survey of Toxic Organic Constituents in the Atlantic Region's aquatic environment 1979-81", will guide the agencies which form the "Regional Toxic Chemicals Committee" (RTCC) in planning future activities.

Yours sincerely,

D. H. Cullen, Chief
Water Quality Branch

ABSTRACT

In order to identify and quantify some of the toxic organic chemicals in the aquatic environment, eighty-four sites in the Atlantic Provinces were sampled over a three-year period (1979-81) and screened for one or more of the following: carbofuran, chlorobenzenes, mirex, pentachlorophenol, phthalic acid esters, polynuclear aromatic hydrocarbons, polychlorinated biphenyls and/or triaryl phosphates. This survey resulted in the identification of a number of areas with measurable concentrations of organic chemicals suggesting anthropogenic influences.

RESUME

En vue d'identifier et quantitifier quelques-uns des produits organiques toxiques présents dans l'environnement aquatique, quatre-vingts sites dans les provinces de l'Atlantique furent échantillionnés durant une période de trois ans (1979-81). Les paramètres recherches furent un ou plusieurs des suivants: le carbofuran, les chlorobenzenes, le mirex, le pentachlorophenol, les esters de l'acide phthalique, les hydrocarbures polynucléaires aromatiques, les biphényls polychlorés et/ou les phosphates triaryl. Le relevé suggère une influence anthropogénique, ceci dû au fait que l'identification d'un certain nombre de régions démontre des concentrations mesurables de produits chimiques organiques.

TABLE OF CONTENTS

LETTER OF TRANSMITTAL I

ABSTRACT/RESUME II

1 INTRODUCTION 1

2 BACKGROUND 2

2.1 Sampling Program 2

2.2 Parameter 3

2.3 Field Methodology 3

2.4 Laboratory Methodology 5

3 RESULTS AND DISCUSSION 11

3.1 Data Screening 11

3.2 Chlorinated Benzenes 12

3.3 Mirex and Organochlorine Pesticides 13

3.4 Pentachlorophenols 13

3.5 Polychlorinated Biphenyls 14

3.6 Polynuclear Aromatic Hydrocarbons 15

3.7 Triaryl Phosphates 17

4 CONCLUSION 18

REFERENCES 20

LIST OF TABLES 24

APPENDIX I - Sampling Sites 40

MAP #1 - New Brunswick 48

MAP #2 - Nova Scotia 49

MAP #3 - Prince Edward Island 50

MAP #4 - Newfoundland 51

APPENDIX II - Sources, Applications and Chemical Properties.. 52

1.1 Carbofuran 52

1.2 Chlorinated Benzenes 53

1.3 Mirex and Organochlorine Pesticides 54

1.4 Pentachlorophenol 55

1.5 Phthalic Acid Esters 55

1.6 Polychlorinated Biphenyls 57

1.7 Polynuclear Aromatic Hydrocarbons 58

1.8 Triaryl Phosphate 59

1. INTRODUCTION

Toxic substances, by definition, cause harmful biological effects in humans and other organisms in the environment. They are widely dispersed in the environment, are highly persistent, may be accumulated in biological tissue and cause biological changes even in trace concentrations. Effective management of these chemical substances requires a prediction of the likely manner of their entry into the environment and scientific data on their concentration, persistence and ultimate fate.

In response to this concern, the Environmental Conservation Service of Environment Canada has developed a program with the objective of identifying and quantifying toxic chemicals.

The long term objective of the Water Quality Branch Toxic Chemicals Program, in the Atlantic Region, is to characterize and measure the extent of contamination in the aquatic environment. The results obtained can thereafter be employed by water resource managers as input to the planning, development and implementation of regulations and controls.

The aim of this study was to screen selected basins in the four Atlantic Provinces for the presence of carbofuran, chlorobenzenes, mirex, pentachlorophenol, phthalate esters, polyaromatic hydrocarbons, polychlorinated biphenyls and triaryl phosphates. The media investigated were the water column and, when present, bottom sediment. The overall

objective was to report on their range of concentration in the aquatic environment.

During the three year period 1979-81, a total of eighty-four sites were sampled in triplicate with some sites being revisited two or three times. Each sample was analyzed by the Water Quality Branch Laboratory in Moncton, N. B. for one or more of the parameters under investigation. This report summarizes the results obtained by this three year survey and identifies areas where measurable values were observed.

2. BACKGROUND

2.1 Sampling Program

In total, eighty-four sites were selected with the following provincial breakdown: thirty-one in New Brunswick, thirty-two in Nova Scotia, eleven in Prince Edward Island and ten in Newfoundland. A description of each sampling site is detailed in Appendix I. In addition, this Appendix also lists the appropriate NAQUADAT station designation (1) for each of these sites. Provincial maps, identifying the location of each site sampled, are also appended.

The sampling program consisted of three phases, each covering one year of the three-year survey. The sampling distribution by Province for each phase is listed in Table 1.

Sampling in each phase was conducted in late summer or early fall and consisted of collecting triplicate water and, bottom sediment samples.

2.2 Parameters

The seven toxic organic constituents selected for this survey were carbofuran, chlorobenzenes (CB), mirex, organochlorines, pentachlorophenol (PCP), phthalic acid esters (PAE), polynuclear aromatic hydrocarbons (PAH), polychlorinated biphenyls (PCB) and triaryl phosphates. The parameter selection was based on Environment Canada's Priority Chemical List, data needs in the Atlantic Region and availability of approved Water Quality Branch analytical methodology. The parameters analyzed, in each phase of the survey are given in Table 2. A general discussion on the sources, applications and chemical properties of the organic chemicals is presented in Appendix II.

2.3 Field Methodology

Water samples were collected, at a depth of approximately 0.3 m using a triplicate iron sampler. In 1979, all samples for organic analysis were collected in 1.2 L (40 oz.) green glass liquor bottles with a tin-foil liner to isolate the sample from the plastic cap, whereas in 1980 and 1981, 1.0 L amber glass solvent bottles with a teflon liner were used. All bottles were washed, rinsed with acetone and

hexane, and baked at 300°C. Triplicate samples were collected for each parameter or parameter group in 1979 and 1981. In 1980, however, parameters with common extraction procedures were sampled and extracted simultaneously (Chlorobenzenes / polyaromatic hydrocarbons and phthalate esters / triaryl phosphates).

The methods for preservation of the organic constituents are summarized in Table 3. All samples were stored at 4°C prior to analyses.

Bottom sediment samples were collected using a 15 x 15 cm Ekman Grab Sampler. Once collected, the sediment sample was carefully released from the sampler into a clean Pyrex tray. The sediment was subsequently sub-sampled by taking approximately 0.5 kg of the top 1.0-2.5 cm with an aluminum scoop. This subsample was placed in a pre-washed Mason jar (1979) or a Reynolds Aluminum Freezer Storage container (1980 and 1981). The whole sampling and sub-sampling procedure was repeated until three independent bottom sediment samples had been collected. During the first year (1979), the sediment samples were stored in a cool dry place while being transported to the Water Quality Branch Laboratory. In 1980 and 1981 the samples were stored in a mobile laboratory freezer until they reached their destination.

All water and sediment samples were returned to the Water Quality Branch Laboratory within four days of their collection except those originating from Newfoundland which were returned within nine days.

2.4 Laboratory Methodology

Analyses were performed using the standard analytical procedures described in the Water Quality Branch Analytical Methods Manual (2) as well as methods adopted from other sources. The specific methods employed, identified by their respective NAQUADAT Parameter Codes (3), are summarized as follows:

a) Carbofuran in water

Carbofuran in water was determined using method 89271L. The water samples were adjusted to pH 2 and sodium sulphate was added. The sample was then extracted with methylene chloride and dried using anhydrous sodium sulphate. The extract was concentrated and made up to a final volume of 2 mL in hexane. Carbofuran was measured directly by gas-liquid chromatography using a nitrogen/phosphorus selective detector. The detection limit for the method is 0.1 ug/L.

b) Carbofuran in sediments

Carbofuran in sediment was determined using method 89272L. Sediment samples of approximately 10 grams dry weight were extracted with ethyl acetate using a Polytron Ultrasonic Homogenizer. The extracts were cleaned up, dried and brought to a final volume of 2 mL with ethyl acetate. Analysis was carried out by gas-liquid chromatography using a

nitrogen/phosphorus selective detector. The detection limit for the method is 0.01 mg/kg.

c) Chlorinated Benzenes in Water

The water samples were extracted with hexane. The extract was dried through sodium sulfate, concentrated, cleaned up on a florisil column and analyzed by gas liquid chromatography in 1979 and by capillary gas-liquid chromatography in 1980. The NAQUADAT parameter codes and detection limits are summarized in Table 4.

d) Chlorinated Benzenes in Sediment

The sediment was extracted with acetone. This extract was diluted with water and extracted with hexane. The hexane extract was dried, concentrated and cleaned up on a florisil column. Gas-liquid chromatography was used for measurement and identification in 1979, whereas capillary gas-liquid chromatography was used in 1980. The NAQUADAT parameter codes and detection limits are summarized in Table 4.

e) Mirex and Organochlorines in Water

A one liter sample was extracted with hexane, and the extract was concentrated and dried. This solution was then chromatographed on a florisil column for preliminary separation. The eluates were concentrated then injected into a gas-liquid chromatograph with an

electron capture detector. The NAQUADAT parameter codes and detection limits are summarized in Table 5.

f) Mirex and Organochlorines in Sediment

A 10 gram sample (dry weight) of sediment was extracted in a Waring blender with acetonitrile, diluted with water and then partitioned with petroleum ether. The organic phase was washed with water, dried and concentrated. The concentrated extract was then purified by cleaning on a florisil column. The samples were analyzed on a gas-liquid chromatograph with an electron capture detector. The parameter codes and detection limits are summarized in Table 5.

g) Pentachlorophenol in Water

Pentachlorophenol was determined by method 17803L. After extraction with benzene, the PCP was extracted from the benzene with a 0.1 molar solution of K_2CO_3. The PCP was derivatized by acetylation with the addition of acetic anhydride to the carbonate solution. The pentachlorophenol acetate was then extracted into hexane and quantitation was achieved via electron capture gas-liquid chromatography. The detection limit is 0.01 ug/L.

h) Phthalic Acid Esters in Water

Phthalic acid esters in a water sample were partitioned into

methylene chloride. The residue was then concentrated by evaporating the organic solvent to a small volume of which an aliquot was analyzed by High Pressure Liquid Chromatography (HPLC) using a reverse phase column and a UV absorption detector. The parameter codes and detection limits are summarized in Table 6.

i) Phthalic Acid Esters in Sediment

Sediment samples, approximately 10 grams dry weight, were homogenized with acetonitrile by means of a Polytron Homogenizer. After having added water to acetonitrile extract, phthalic acid esters were partitioned into methylene chloride. The methylene chloride was evaporated and replaced with hexane. The concentrated extract in hexane was subsequently cleaned up by fractionation on a florisil column and the respective fractions were analyzed by HPLC. The NAQUADAT parameter codes and detection limits are summarized in Table 6

j) Polynuclear Aromatic Hydrocarbons in Water

Polynuclear Aromatic Hydrocarbons in water were extracted with hexane. The dried and concentrated extract was then cleaned up on an alumina column and subjected to HPLC analysis with gradient elution on a suitable reverse phase column. Identification and quantitation was accomplished with a fluorescence detector. The parameter codes and detection limits for the method are summarized in NAQUADAT Table 7.

k) Polynuclear Aromatic Hydrocarbons in Sediment

Sediment samples (10 grams dry weight) were extracted with acetonitrile with a Polytron Homogenizer. After having decanted the acetonitrile, water was added and the PAH's were extracted with hexane. The dried and concentrated extract was then cleaned up on an alumina column and subjected to HPLC analysis with gradient elution on a suitable reverse phase column. Identification and quantitation was accomplished with a fluorescence detector. The NAQUADAT parameter codes and detection limits for the method are summarized in Table 7.

l) Polychlorinated Biphenyls in Sediment

The method employed in 1979 was identical to the one used to determine Mirex and organochlorine pesticides. The parameter code was 18169 with a detection limit of 0.005 mg/kg. In 1981, a sonification method with hexane/acetone replaced the Waring blender and acetonitrile. The parameter code for this method is 18177 and has a detection limit of 0.005 mg/kg.

m) Triaryl Phosphates in Water

The triaryl phosphates in a water sample were extracted into methylene chloride and the extract was concentrated with solvent exchange into hexane. The compounds were determined by gas-liquid chromatography with a nitrogen-phosphorus selective flame ionization

detector or flame photometric detector. A summary of parameter codes and detection are listed in Table 8.

3. RESULTS AND DISCUSSION

3.1 Data Screening

Table 9 lists the sites sampled and parameters analysed for at each site during the survey. Table 10 summarizes the results of the three year screening for the presence of eight toxic organic chemicals in the Atlantic provinces. Carbofuran was below the detection limit in all the samples and thus will not be considered in the following discussion. However, this should not be construed as evidence that use of carbofuran is not of concern in the Atlantic Region as the survey was not originally designed for pesticide parameters and thus all of the twenty-one sites were located in areas of limited agricultural use. In addition to carbofuran, results of phthalic acid esters will not be discussed. Although positive values were observed, there were obvious problems with contamination and thus no confidence can be placed in the results. Analysis of dichlorobenzenes in sediments in 1979 was subject to methodological interference therefore the remaining chlorinated benzenes data have a low confidence level and have been omitted. In 1980, a more sensitive capillary gas-liquid chromatography method for chlorobenzene was adopted, however no value above the detection limit was recorded, therefore chlorobenzenes in sediments will not be included in the discussion.

3.2 Chlorinated Benzenes

Water samples were collected for chlorinated benzenes during all phases of the survey. All samples were analyzed for three dichloroisomers three trichloroisomers, three tetrachloroisomers, pentachloro and hexachlorobenzenes.

Chlorinated benzenes were not detected in any of the thirty-three samples collected in 1979. However, nine of forty-five sites in 1980 and two of twenty-four sites sampled in 1981 gave positive values at or near the detection limit (Table 11). Although a cross-section of chlorinated benzenes was represented, the values were insignificant with respect to the EPA guidelines. The lack of detectable values during 1979 is probably a function of the sensitivity of the analytical technique employed. In 1980 and 1981 a technique approximately 5 times more sensitive than that used in 1979 gave numerous positive values of which the majority were below the 1979 detection limit. Total chlorinated benzene concentrations ranged from 0.01 ug/L to 0.20 ug/L with a median value of 0.03 ug/L.

As a sub-survey of the Toxic Chemicals Program, a screening of the Annapolis River basin for chlorinated benzenes was carried out during September, 1981. This was in response to positive values in sediments observed during the 1979 survey and included the sampling of seven sites located between Aylesford and Annapolis Royal. Chlorinated benzenes were not detected in any of the water samples. However two

sites had sediment concentrations of hexachlorobenzenes near the detection limit (0.001 and 0.004 mg/kg). Three sites were sampled during both low and high flow conditions, however there was no indication that chlorinated benzene concentrations were related to surface run-off.

3.3 Mirex and Organochlorine Pesticides

Mirex was not detected in either water or sediment samples collected from thirty-four and nineteen sites respectively. Other organochlorine pesticides were not observed in any of the water samples however, 14 of 19 sediment samples had detectable values (Table 12). With the exception of one Prince Edward Island site having detectable levels of endrin, the positive sediment results were characteristically DDT or DDT metabolites. Total organochlorine pesticide levels ranged from 0.001 to 0.166 with a median value of 0.008.

3.4 Pentachlorophenol

Water samples were collected during both 1979 and 1980 for determination of pentachlorophenols. In 1979 seven of the thirty-three sites sampled had detectable levels, six of which were found in Prince Edward Island and one in New Brunswick. In 1980, a further forty-four samples were collected with positive values detected for two sites in Nova Scotia (Table 13). These values were both at the detection limit. The combined range for the two years was from the 0.01 detection limit to a maximum value of 0.10 mg/L and had a median value of 0.03 mg/L.

Pentachlorophenols are not persistent in water, but are sorbed by organic matter in the freshwater ecosystem (EPA, 11). This would account for the small number of positive values detected in the water column during the survey, even at sites below documented users of pentachlorophenols (12). Unfortunately the analytical technique for the determination of PCP in sediments was not available, so it was not possible to determine whether the sediments were acting as a pentachlorophenols sink.

3.5 Polychlorinated Biphenyls

Bottom sediment samples for polychlorinated biphenyl determination were collected from a total of forty-six sites during all three phases of the survey. Of these sites, a total of thirty-nine had PCB concentrations above the detection limit of 0.005 mg/kg. Five other sites had concentrations at or below the detection limit (Table 14). These positive results were widely distributed throughout the Atlantic Region. This ubiquitous nature may be the consequence of the volatilization and/or aerosol dispersion of PCB's.

Of the thirty-nine sites exhibiting positive results, twenty-nine sites had triplicate average concentrations of less than 0.1 mg/kg, six had values ranging from 0.1 mg/kg to 0.5 mg/kg and the final four sites exceeded the 0.5 mg/kg level. The overall range of values was from L.005 mg/kg to 1.04 mg/kg and had a median value of 0.022 mg/kg.

The four values greater than 0.5 mg/kg were Nepisiquit River (0.73 mg/kg - based on a single sample), St. John's Harbour (0.75 mg/kg - based on a split sample), Summerside Harbour (0.76 mg/kg) and the Strait of Canso (1.04 mg/kg). The values for St. John's Harbour correlate well with a survey of four harbours in the Atlantic Region by Environmental Protection Service of Environment Canada in 1976. The values for Summerside greatly exceeds the value of 0.016 mg/kg for one sample collected at a different site previously analyzed under the Ocean Dumping Control Act (ODCA). No existing data are available for the remaining two sites. A plausible source for the high values in the triplicates from the Strait of Canso is indicated in the publication "PCB in the Atlantic Provinces" where it's reported that in 1977 effluent to the Strait from Nova Scotia Forest Industries contained 0.08 mg/L PCB.

3.6 Polynuclear Aromatic Hydrocarbons

Water samples for polynuclear aromatic hydrocarbons analyses were collected during 1980 and 1981. Of the sixty-eight samples collected, a total of sixteen had detectable levels of PAH's (Table 15).

The six polynuclear aromatic hydrocarbons outlined by the World Health Organization, and listed in Appendix I were analyzed for during this survey. Fluoranthene, the PAH most soluble in water, was detected in all sixteen samples with positive total PAH values. The total PAH

average of the sixteen triplicate samples ranged from 0.005 ug/L to 0.129 ug/L with a median value of 0.009 mg/kg.

Only two sites had elevated PAH values and these were still well below the WHO recommendation of 0.200 ug/L for drinking water. Sydney Harbour with a total PAH average of 0.130 ug/L had positive values of five of the six PAH's, although most were near the detection limits except for fluoranthene. A tar pit associated with Sydney Steel Corp., is believed responsible for the above average levels which are more dramatic in the sediments. A comprehensive survey of Sydney Harbour for PAH's was undertaker by Environmental Protection Service of Environment Canada in 1981. St. John's Harbour site averaged 0.090 ug/L, although only fluoranthene was detected.

Polynuclear aromatic hydrocarbons were detected in all of the forty-two triplicate bottom sediment samples collected and all six PAH's were represented in many samples (Table 16).

The PAH range was 0.018-28 mg/kg with a median value of 0.261 mg/kg. The PAH values for all sediment samples collected at Sydney Harbour were exceedingly high in relation to other sites. The total PAH average for the three Sydney Harbour sediment samples was 28 mg/kg with individual PAH averages of 16 mg/kg for fluoranthene, 7.3 mg/kg for benzo [a] pyrene, and 2.4 mg/kg each for benzo [b] and benzo [k] fluoranthene. McLaren Plansearch (25) found indeno-1,2,3-(cd) pyrene and benzo (GHI) Perylene were the highest (by GC/MS analysis) in the Sydney Steel

Company effluent in 1980. However, these PAH's were not detected in the Sydney Harbour samples collected in this survey.

With the exception of Sydney Harbour, PAH's in the region, though widespread, do not appear to be a problem. Many pristine sites had total PAH averages above the median value. In New Brunswick, Lake Nictau and Magaguadavic Lake exceeded the median with values of 0.606 mg/kg and 0.459 mg/kg respectively. In Nova Scotia, sites such as Lake Rossignol (0.30 mg/kg) and Mira River (0.60 mg/kg) also exceeded the median. It should be noted that many of the background sites had positive values for all six PAH's perhaps indicating natural inputs.

3.7 Triaryl Phosphates

Forty-six water samples were collected during the survey for determination of triaryl phosphate concentrations. Of these forty-six samples, detectable levels were found only in the one triplicate sample collected from St. John's Harbour. Of the five triaryl phosphates analyzed (diphenyl cresyl phosphate, triphenyl phosphate, tri-o-tolyl phosphate, tri-m-tolyl phosphate and tri-p-tolyl phosphate) only one, triphenyl phosphate, was detected in St. John's Harbour at a concentration of 0.23 mg/L. Triphenyl phosphate is the most acutely toxic triaryl phosphate, having LC 50 values of 300-400 ug/L (0.30 to 0.40 mg/L) for rainbow trout fry and fingerlings (Muir et al. (27)). The source of triphenyl phosphate is not presently known.

4. CONCLUSION

The purpose of this study was to locate and quantify some of the toxic organic chemicals in the aquatic environment of Atlantic Canada. In support of this three years' study, water and/or sediment samples were collected at eighty-four sites and analyzed for one or more of the parameters discussed in this report.

The results indicated that carbofuran, chlorinated benzenes, mirex and O.C. pesticides, pentachlorophenol and triaryl phosphates did not have a significant presence in the region. These parameters were not detected or if present, the values were near the detection limit.

Polychlorinated biphenyls (PCB's) were widespread with thirty-nine of forty sites reporting low to moderate values in bottom sediments. Four sites had significant average values exceeding documented data: Nepisiquit River, St. John's Harbour, Summerside Harbour and Strait of Canso.

Polynuclear aromatic hydrocarbons were detected in water samples in all provinces but at levels well below the WHO guideline for drinking water of 0.200 ug/L. PAH's were detected in bottom sediment at all forty-two sites sampled with extremely high values in samples collected at Sydney Harbour. The triplicate sediment average of 28 mg/kg contained high levels of fluoranthene and benzo(a) pyrene. It was found that PAH concentrations at background sites often surpassed both the provincial

median and that for sites collected near industrialized areas. This raises questions as to the origins and mechanism for distribution of the PAH's.

REFERENCES

(1) NAQUADAT Users Manual; A. Demayo and E. Hunt, Water Quality Branch, Inland Waters Directorate, Ottawa, Ont. (1975).

(2) Analytical Methods Manual; Water Quality Branch, Inland Waters Directorate, Ottawa, Ont. (1979).

(3) NAQUADAT Dictionary of Parameter Codes; S.H. Whitlow, Data and Instrumentation Section, Water Quality Branch, Environment Canada (1982).

(4) CARBOFURAN: Criteria for Interpreting the Effects of its Use on Environmental Quality; National Research Council of Canada, NRCC No. 16740, 1979.

(5) Atlantic Canada Potato Guide; Atlantic Potato Committee, 1980.

(6) Water Quality Sourcebook; Inland Waters Directorate, Water Quality Branch, Ottawa, Ont. 1979.

(7) List of Priority Chemicals; Environment Canada and National Health and Welfare Environmental Contaminants Committee, 1979.

(8) Mirex in the Sediments of Lake Ontario; M. Van Hove Holdrinet, R. Frank, R.L. Thomas, L.J. Hetling, J. Great Lake Res. March, 1978

(9) Chlorinated Benzenes in Herring Gull and Double-Crested Cormorant Eggs from Three Locations in the Maritime Provinces EPS-5-AR-80-1, R.A.F. Matheson et al., 1980.

(10) Toxic Chemicals: An Atlantic Region Profile; Atlantic Regional Toxic Chemicals Committee, July 1981.

(11) Water-Related Environmental Fate of 129 Priority Pollutants; United States Environmental Protection Agency, December 1979 (EPS-440/4-79-029).

(12) Dioxins in the Vicinity of Two Atlantic Region Wood Preserving Operations; D.J. Baker and R.A.F. Matheson, (EPS-5-AR-81-2), August 1981.

(13) Pentachlorophenol Distribution in a Fresh Water Ecosystem; R.H. Pierce, C.R. Brent, H.P. William, S.G. Reeves, Bull. Envir. Contam. and Tox. Vol. 18, No. 2: 251-257, 1977.

(14) Environmental Contaminants Inventory Study No. 4 - The Production, Use and Distribution of Phthalic Acid Esters in Canada; Report Series No. 47, T.D. Leah, Fisheries and Environment Canada, 1977

(15) Canadian Use Pattern Survey of Organotins, Phthalate Esters

and Triaryl Phosphates; Martec, Ms. Report, August 1979, 62 p.

(16) Phthalate Esters in the Aquatic Environment; R.C. Pierce, S.P. Mathers, D.T. Williams, M.J. Boddington, NRCC No. 17583, 1980.

(17) Phthalic Acid Esters in Water; M. Morita, H. Nakamura, and S. Minura, Water Research 8:781-788, 1974.

(18) Organic Compounds in the Delaware River; L.S. Sheldon and R.A. Hites, Envir. Sc. and Tech. 10:1109-1230, 1978.

(19) PCBs in the Atlantic Provinces; I. Travers and R.C.H. Wilson, EPS-5-AR-77-13, 1977.

(20) Disposing of a Hazardous Legacy - PCBs; S. Beszedits and Dr. A. Netzer, Water and Pollution Control, Jan/Feb.:23-27, 1982.

(21) Polychlorinated Biphenyls: Biological Criteria for an Assessment of their Effects on Environmental Quality; J.R. Roberts, D.W. Rodgers, J.R. Bailey, M.A. Rorke, NRCC No. 16077, 1978.

(22) Sorption of Polynuclear Aromatic Hydrocarbons by Sediments and Soils; Jacq C. Means, Susanne Wood, John J. Hassett and Wayne Bohwart, Envir. Sc. Tech. Vol. 14, No. 12:1524-1529, December 1980.

(23) Toxic Substances Control Sourcebook; Ed. A. McRae, L. Whelchel, The Centre for Compliance Information, 1978.

(24) PAH in Water Systems; David Putona, S. Ruven Smith, Trudy Smith, John Tanaka, CRC Press, 1981.

(25) Polyaromatic Hydrocarbons in Industrial Effluents; MacLaren Plansearch, Report to Environment Canada, Feb. 1981.

(26) Acute Toxicity of Phosphate Ester Mixtures to Invertebrate and Fish; Michel J. Nevins and W. Waynon Johnson, Bull. Environ. Contam. Toxicol. 19:250-255, 1978.

(27) Determination of Several Triarylphosphates in Fish and Sediment Samples; D.C.G. Muir, N.P. Frift and J. Solemon, Department of Fisheries and Oceans, Freshwater Institute, 1980.

(28) Chlorobenzenes in Sediments, Water and Selected Fish for Lakes Superior, Huron, Erie and Ontario; Barry G. Oliver and Karen D. Bothen, National Water Research Institute, CCIW, 1981.

(29) Potential Halogenated Industrial Carcinogenic and Mutagenic Chemicals; Lawrence Fishbein, The Science of the Total Environment, 11, (1979) 259-278.

LIST OF TABLES

PAGE

1. Summary of Sites Sampled in each Phase 26
2. Parameter Analyzed in each Phase 26
3. Preservation of Organic Constituents 27
4. Chlorinated Benzene Parameter Codes and Detection Limits 28
5. Mirex and O.C. Pesticides - Parameter Codes and Detection Limits 29
6. Phthalic Acid Esters - Parameter Codes and Detection Limits 29
7. Polynuclear Aromatic Hydrocarbons - Parameter Codes and Detection Limits 30
8. Triaryl Phosphates - Parameter Codes and Detection Limits 30
9. Sampling Sites and Parameters Analysed During the Study Period 31
10. Summary of Number of Samples Collected and the Positive Values Recorded for seven groups of Organic Compounds 35
11. Concentrations of Total Chlorinated Benzenes in Water Samples Collected from Selected Sites in the Atlantic Region 35
12. Organochlorine Pesticide Concentrations in

Sediments Collected from Selected Sites
in the Atlantic Region 36

13. Pentachlorophenol Concentrations in Water
Samples Collected from the Atlantic Region 36

14. Polychlorinated Biphenyl Concentrations in
Sediments Collected at Selected Sites in
the Atlantic Region 37

15. Concentrations of Total Polyaromatic Hydrocarbons
in Water Samples Collected from Selected Sites
in the Atlantic Region 38

16. Concentrations of Total Polyaromatic Hydrocarbons
in Sediments Collected from Selected Sites in
the Atlantic Region 39

TABLE 1

SITES SAMPLED

PROVINCE	PHASE I (1979)	PHASE II (1980)	PHASE III (1981)
New Brunswick	15	14	11
Nova Scotia	13	15	17
Prince Edward Island	6	6	5
Newfoundland	NIL	10	NIL

TABLE 2
PARAMETERS ANALYZED IN EACH PHASE

MEDIA	PHASE I (1979)	PHASE II (1980)	PHASE III (1981)
Water	Chlorinated Benzene Mirex Pentachlorophenol Phthalic Acid Esters	Chlorinated Benzene Pentachlorophenol Phthalic Acid Esters Polynuclear Aromatic Hydrocarbons Triaryl Phosphates	Carbofuran Chlorinated Benzenes Polynuclear Aromatic Hydrocarbons
Bottom Sediment	Chlorinated Benzenes Mirex Phthalic Acid Esters Polychlorinated Biphenyls	Chlorinated Benzenes Polynuclear Aromatic Hydrocarbons	Carbofuran Polynuclear Aromatic Hydrocarbons Polychlorinated Biphenyls

TABLE 3

PRESERVATION OF ORGANIC CONSTITUENTS IN WATER SAMPLES

Parameter	Preservation
Carbofuran	30 mL hexane
Chlorinated Benzenes	30 mL hexane
Mirex and Organochlorines Pesticides	100 mL hexane
Pentachlorophenol	1 gram $CuSO_4$, 0.5 mL 50% H_2SO_4 and 30 mL hexane
Polynuclear Hydrocarbons	30 mL hexane
Triaryl Phosphates	30 mL methylene chloride

TABLE 4

CHLORINATED BENZENES NAQUADAT PARAMETER CODES AND DETECTION LIMITS

Parameter	Water(a)		Sediment(a)	
	Parameter Codes	D.L. ug/L	Parameter Codes	D.L. mg/kg
1,3-Dichlorobenzene	89834	0.1	89835	0.02
1,4- "	89836	0.1	89837	0.02
1,2- "	89832	0.1	89833	0.02
1,3,5-Trichlorobenzene	89850	0.01	89851	0.002
1,2,4- "	89840	0.01	89841	0.002
1,2,3- "	89838	0.01	89839	0.002
1,2,3,5-Tetrachlorobenzene	89852	0.01	89853	0.002
1,2,4,5- "	89844	0.01	89845	0.002
1,2,3,4- "	89842	0.01	89843	0.002
Pentachlorobenzene	89846	0.01	89847	0.002
Hexachlorobenzene	89848	0.01	89849	0.002
		1980(b)		
1,3-Dichlorobenzene	17820	0.02	89835	0.002
1,4- "	17821	0.02	89837	0.002
1,2- "	17822	0.02	89833	0.002
1,3,5-Trichlorobenzene	17830	0.004	89851	0.0004
1,2,4- "	17831	0.004	89841	0.0004
1,2,3- "	17832	0.004	89839	0.0004
1,2,3,5-Tetrachlorobenzene	17840	0.002	89853	0.0002
1,2,4,5- "	17841	0.002	89845	0.0002
1,2,3,4- "	17842	0.002	89843	0.0002
Pentachlorobenzene	17850	0.002	89847	0.0002
Hexachlorobenzene	17812	0.002	89849	0.0002

(a) 89—— series parameter codes are WQB in-house codes

(b) The same in-house parameter codes were used for both the 1979 and 1980 sediments. The same methodology was employed both years except a change in instrumentation - conventional gas liquid chromatography to capillary gas liquid chromatography- allowed for improved detection limits.

TABLE 5

MIREX AND ORGANOCHLORINE PESTICIDES - NAQUADAT PARAMETER CODES AND DETECTION LIMITS

Parameter	Water		Sediment	
	Parameter Code	D.L. ug/L	Parameter Code	D.L. mg/kg
p,p'-DDT	18000	0.001	18001	0.001
o,p'-DDT	18005	0.001	18006	0.001
p,p'-DDD	18010	0.001	18011	0.001
p,p'-DDE	18020	0.001	18021	0.001
p,p'-Methoxychlor	18030	0.01	18031	0.05
Heptachlor	18040	0.001	18041	0.001
Heptachlor epoxide	18045	0.001	18046	0.001
-Endosulphan	18050	0.01	18051	0.01
-Endosulphan	18055	0.01	18056	0.01
-Chlordane	18060	0.005	18061	0.005
-Chlordane	18065	0.005	18066	0.005
Lindane	18070	0.001	18071	0.001
-BHC	18075	0.001	18076	0.001
Mirex	18125	0.001	18129	0.001
Aldrin	18130	0.001	18131	0.001
Endrin	18140	0.01	18141	0.01
Dieldrin	18150	0.001	18151	0.001

TABLE 6

PHTHALIC ACID ESTERS - NAQUADAT PARAMETER CODES & DETECTION LIMITS

Parameter	Water		Sediment	
	Parameter(a) Code	D.L. ug/L	Parameter(b) Code	D.L. mg/kg
Dimethyl Phthalate	89730(a)	0.5	89731	0.04
Diethyl Phthalate	89734	0.7	89735	0.05
Dibutyl Phthalate	89738	0.8	89739	0.05
Diethylhexyl Phthalate	89740	0.9	89741	0.07
Dipropyl Phthalate	89742	1.1	89743	0.08
Dioctyl Phthalate	89744	0.9	89744	0.06

(a) 89—— series parameter codes are WQB in-house codes.

TABLE 7
POLYNUCLEAR AROMATIC HYDROCARBONS - PARAMETER CODES & DETECTION LIMITS

Parameter	Water		Sediment	
	Parameter Code	D.L. ug/L	Parameter Code	D.L. mg/kg
Fluoranthene	18904	0.005	18914	0.001
Benz(b) fluoranthene	18901	0.003	18911	0.0007
Benz(k) fluoranthene	18903	0.002	18913	0.0003
Benz(a) pyrene	18900	0.003	18910	0.0007
Indeno (1,2,3,cd) pyrene	18905	0.005	18915	0.001
Benzo(g,h,i) perylene	18902	0.006	18912	0.001

TABLE 8
TRIARYL PHOSPHATES - NAQUADAT PARAMETER CODES & DETECTION LIMITS

Parameter	Water	
	Parameter Code	D.L. ug/L
Tri-phenyl phosphate	89904	0.003
Tri-o-tolyl phosphate	89906	0.004
Tri-m-tolyl phosphate	89908	0.004
Tri-p-tolyl phosphate	89912	0.009

Table 9: Sampling Sites and Parameters Analysed During the Study Period (underlined symbols indicate concentrations above the detection limit)

Site	Year	Water							Sediment					
		Carbofuran	Chlorinated Benzenes	Kirex	Pentachlorophenol	Phthalatic Acid Esters	PAH(1)	Triaryl Phosphates	Carbofuran	Chlorinated Benzenes	Kirex	Phthalatic Acid Esters	PCB(2)	PAH(1)
1	1981	X	X				X		X				X	X
2	1981	X	X				X							
3	1979		X	X	X	X								
	1980		X		X	X	X	X						
4	1979		X	X	X	X				X	X	X	X	
	1981	X	X				X		X				X	X
5	1979		X	X	X	X				X	X	X	X	
	1980		X		X	X	X	X		X				X
6	1981	X	X				X		X				X	X
7	1981	X	X				X		X				X	X
8	1981	X	X				X		X				X	X
9	1981	X	X				X		X				X	X
10	1979		X	X	X	X								
	1980		X		X	X	X	X						
11	1981	X	X				X		X				X	X
12	1981	X	X				X		X				X	X
13	1979		X	X	X	X				X	X	X	X	
14	1980		X		X	X	X	X		X				X
15	1981	X	X				X		X				X	X
16	1979		X	X	X	X								
	1980		X		X	X	X	X						
17	1979									X	X	X	X	
18	1980									X				X
19	1981	X	X				X		X				X	X
20	1979		X	X	X	X								
	1980		X		X	X	X	X						
21	1979		X	X	X	X				X	X	X	X	
	1980		X		X	X	X	X		X				X
22	1981	X	X				X		X				X	X
23	1979		X	X	X	X								
	1980		X		X	X	X	X						
24	1979									X	X	X	X	
25	1980		X		X	X	X	X		X				X
26	1979		X	X	X	X				X	X	X	X	

(1) Polyaromatic Hydrocarbons (2) Polychlorinated Biphenyls

Site	Year	Water							Sediment					
		Carbofuran	Chlorinated Benzenes	Mirex	Pentachlorophenol	Phthalatic Acid Esters	PAH[1]	Triaryl Phosphates	Carbofuran	Chlorinated Benzenes	Mirex	Phthalatic Acid Esters	PCB[2]	PAH[1]
27	1979		X	X	X	X								
	1980		X		X	X	X	X						
28	1979		X	X	X	X								
	1980		X		X	X	X	X						
29	1980		X		X	X	X	X		X				X
30	1979		X	X	X	X				X	X	X	X	
31	1981	X	X				X		X				X	X
32	1981		X											
33	1981		X											
34	1981		X											
35	1981		X											
36	1981		X											
37	1981		X							X				
38	1979		X	X	X	X				X	X	X	X	
	1980		X		X	X	X	X		X				X
	1981		X							X				
39	1979		X	X	X	X								
	1980		X		X	X	X	X						
40	1981	X	X				X		X				X	X
41	1981	X	X				X		X				X	X
42	1979		X	X	X	X				X	X	X	X	
43	1980		X		X	X	X	X						
44	1979		X	X	X	X								
	1980		X		X	X	X	X						
45	1981	X	X				X		X				X	X
46	1979		X	X	X	X				X	X	X	X	
47	1981	X	X				X		X				X	X
48	1981	X	X				X		X				X	X
49	1981	X	X				X		X				X	X
50	1980		X		X	X	X	X		X				X
51	1979		X	X	X	X								
	1980		X		X	X	X	X						
52	1981	X	X				X		X				X	X

(1) Polyaromatic Hydrocarbons

(2) Polychlorinated Biphenyls

Site	Year	Water							Sediment					
		Carbofuran	Chlorinated Benzenes	Mirex	Pentachlorophenol	Phthalatic Acid Esters	PAH(1)	Triaryl Phosphates	Carbofuran	Chlorinated Benzenes	Mirex	Phthalatic Acid Esters	PCB(2)	PAH(1)
53	1980		X		X	X	X	X		X				X
54	1979		X	X	X	X				X	X	X	X	
	1980		X		X	X	X	X		X				X
55	1979		X	X	X	X								
	1980		X		X	X	X	X						
56	1979		X	X	X	X				X	X	X	X	
	1980		X		X	X	X	X		X				X
57	1981	X	X				X		X				X	X
58	1979		X	X	X	X								
	1980		X		X	X	X	X						
59	1979		X	X	X	X				X	X	X	X	
	1980		X		X	X	X	X		X				X
60	1981	X	X				X		X				X	X
61	1979		X	X	X	X								
	1980		X		X	X	X	X						
62	1981	X	X				X		X				X	X
63	1979		X	X	X	X				X	X	X	X	
	1980		X		X	X	X	X		X				X
64	1979		X	X	X	X				X	X	X	X	
	1980		X	X	X	X	X	X		X				X
65	1981	X	X				X		X				X	X
66	1979		X	X	X	X								
	1980		X		X	X	X	X						
67	1979		X	X	X	X				X	X	X	X	
	1980		X		X	X	X	X		X				X
68	1979		X	X	X	X				X	X	X	X	
	1980		X		X	X	X	X		X				X
69	1981	X	X				X		X				X	X
70	1981	X	X				X		X				X	X
71	1981	X	X				X		X				X	X
72	1979		X	X	X	X				X	X	X	X	
	1980		X		X	X	X	X		X				X
73	1979		X	X	X	X								
	1980		X		X	X	X	X						
74	1981	X	X				X		X				X	X
75	1980				X	X	X	X			X	X	X	
76	1980				X	X	X	X		X	X	X	X	

(1) Polyaromatic Hydrocarbons (2) Polychlorinated Biphenyls

Site	Year	Water							Sediment					
		Carbofuran	Chlorinated Benzenes	Mirex	Pentachlorophenol	Phthalatic Acid Esters	PAH(1)	Triaryl Phosphates	Carbofuran	Chlorinated Benzenes	Mirex	Phthalatic Acid Esters	PCB(2)	PAH(1)
77	1980				X	X	X	X		X	X	X	X	
78	1980				X	X	X	X		X	X	X	X	
79	1980				X	X	X	X		X	X	X	X	
80	1980				X	X	X	X		X	X	X	X	
81	1980				X	X	X	X		X	X	X	X	
82	1980				X	X	X	X		X	X	X	X	
83	1980				X	X	X	X		X	X	X	X	
84	1980				X	X	X	X		X	X	X	X	

(1) Polyaromatic Hydrocarbons

(2) Polychlorinated Biphenyls

TABLE 10
SUMMARY OF NUMBER OF SAMPLES COLLECTED AND THE POSITIVE VALUES RECORDED FOR SEVEN GROUPS OF ORGANIC COMPOUNDS

Parameter	Water		Sediment	
	Total Samples	Positive Samples	Total Samples	Positive Samples
Carbofuran	21	0	21	0
Chlorinated Benzenes	102	11	37	Co
Mirex & Organochlorine Pesticides	34	0	19	14
Pentachlorophenol	77	9	-	-
Phthalate Esters	76	Co	18	Co
Polychlorinated Biphenyls			47	45
Polynuclear Aromatic Hydrocarbons	68	16	42	42

TABLE 11: CONCENTRATIONS OF TOTAL CHLORINATED BENZENES IN WATER SAMPLES COLLECTED FROM SELECTED SITES IN THE ATLANTIC REGION

Site	Date	Total Chlorinated Benzenes Concentration ug/L
3	1980	0.04
5	1980	0.04
7	1980	0.02
16	1980	0.02
20	1980	0.03
23	1980	0.01
29	1980	0.03
57	1980	0.10
62	1981	0.02
67	1980	0.03
70	1981	0.20

TABLE 12: ORGANOCHLORINE PESTICIDE CONCENTRATIONS IN SEDIMENTS COLLECTED FROM SELECTED SITES IN THE ATLANTIC REGION

Site	DDT and DDT metabolites mg/kg	Total Organochlorine Pesticides mg/kg
5	0.110	0.110
7	0.049	0.049
13	0.001	0.001
17	0.036	0.036
26	0.001	0.001
30	0.001	0.001
38	0.006	0.006
42	0.002	0.002
46	0.003	0.003
54	0.049	0.049
56	0.010	0.010
67	0.106	0.166
72	0.066	0.066

TABLE 13: PENTACHLOROPHENOL CONCENTRATIONS IN WATER SAMPLES COLLECTED FROM THE ATLANTIC REGION

Site	Year	Concentration ug/L
21	1979	0.03
55	1980	0.01
61	1980	0.03
64	1979	0.10
66	1979	0.03
67	1979	0.05
68	1979	0.05
72	1979	0.03
73	1979	0.10

TABLE 14: POLYCHLORINATED BIPHENYL CONCENTRATIONS IN SEDIMENTS COLLECTED AT SELECTED SITES IN THE ATLANTIC REGION

Site	Year	Polychlorinated Biphenyl Concentration (mg/kg)
1	1981	L0.005
4	1979	0.10
4	1981	0.049
5	1979	0.09
6	1980	0.019
7	1979	0.043
8	1981	0.013
9	1981	0.007
11	1981	0.026
12	1981	0.017
15	1981	0.006
17	1979	0.16
19	1981	0.005
21	1979	0.26
22	1981	0.007
24	1979	0.73
26	1979	0.01
30	1979	0.09
31	1981	L0.005
38	1979	L0.005
40	1981	0.014
41	1981	0.007
42	1979	L0.005
45	1981	0.069
47	1981	0.048
48	1981	0.011
49	1981	0.024
52	1981	0.015
54	1981	0.020
56	1981	0.020
57	1981	1.04
60	1981	0.005
62	1981	0.014
63	1979	0.04
65	1981	0.003
68	1979	0.76
69	1981	0.80
70	1981	0.008
71	1981	0.012
72	1979	0.27
74	1981	0.017
78	1980	0.23
81	1980	0.11
84	1980	0.75

TABLE 15: CONCENTRATIONS OF TOTAL POLYAROMATIC HYDROCARBONS IN WATER SAMPLES COLLECTED FROM SELECTED SITES IN THE ATLANTIC REGION

Site	Date	Total Polyaromatic Hydrocarbon Concentrations ug/L
14	1980	0.020
22	1981	0.007
45	1981	0.014
47	1981	0.011
57	1981	0.007
60	1981	0.006
62	1981	0.010
63	1980	0.129
64	1980	0.007
66	1980	0.009
68	1980	0.012
69	1981	0.004
73	1980	0.006
78	1980	0.008
82	1980	0.005
84	1980	0.090

TABLE 16: CONCENTRATIONS OF TOTAL POLYAROMATIC HYDROCARBONS IN SEDIMENTS COLLECTED FROM SELECTED SITES IN THE ATLANTIC REGION

Site	Year	Total Polyaromatic Hydrocarbon Concentration (mg/m^3)
4	1981	0.409
5	1980	0.070
6	1981	0.575
7	1980	0.311
8	1981	0.591
9	1981	0.143
11	1981	0.472
12	1981	0.463
14	1980	0.080
15	1981	0.437
18	1980	1.40
19	1981	0.744
21	1980	0.075
22	1981	0.039
25	1980	0.108
29	1980	0.345
31	1981	0.102
38	1980	0.208
40	1981	0.290
41	1981	0.125
45	1981	0.228
47	1981	0.275
48	1981	0.221
49	1981	0.248
50	1980	0.342
52	1981	0.288
53	1980	0.280
54	1980	0.609
56	1980	0.062
57	1981	0.316
59	1980	0.081
60	1981	0.104
62	1981	0.576
63	1980	28.
65	1981	0.087
67	1980	0.018
68	1980	0.492
69	1981	0.040
70	1981	0.151
71	1981	0.129
72	1980	0.409
74	1981	0.142

APPENDIX I
SAMPLING SITES

Sampling Site #	Description	NAQUADAT #
NEW BRUNSWICK		
1	Glasier Lake, 200 m above outlet of St. Francis River (sampled in 1981)	01NB01AD0004 51NB01AD0004
2	Madawaska River Headpond 50 m from Fraser Pumping Station #2 (sampled in 1979 and 1980)	01NB01AD0005
3	Saint John River, 150 m above dam, Grand Falls (sampled in 1979 and 1980)	01NB01AF0005
4	Saint John River at Grand Falls Headpond, 500 m above dam, Madawaska County (sampled in 1979 and 1981)	01NB01AF0006 52NB01AF0006
5	Aroostook River at Canada-US Border (center of River), Victoria County (sampled in 1979 and 1980)	01NB01AG0002 51NB01AG0002
6	Lake Nictau at centre of Westerly Basin, Restigouche County (sampled in 1981)	01NB01AH0008 51NB01AH0008
7	Saint John River 150 m above dam, Beechwood, Carleton County (sampled in 1981)	01NB01AJ0003 51NB01AJ0003
8	Saint John River at Mactaquac Headpond, 100 m above Headland (sampled in 1981)	01NB01AK0012 51NB01AK0012
9	Grand Lake about 700 m from Jemseg River at black channel marker (sampled in 1981)	01NB01AO0019 51NB01AO0019
10	Saint John River at Lower Gagetown from ferry in midstream, Queens County (sampled in 1979 and 1980)	00NB01AP0035

11	Saint John River, about 1.3 km below ferry at center Westfield (sampled in 1981)	02NB01AP0013 52NB01AP0013
12	Kennebecasis Bay near Gondola Point between Wheatons Pt and Oliver Pt. 150 m from Wheatons Point (sampled in 1981)	02NB01AP0014 52NB01AP0014
13	Saint John Harbour (Courtenay Bay), 1250 m WSW of confluence of Little River (sampled in 1979)	03NB01AP0001 53NB01AP0001
14	Saint John Harbour, 50 m N of Pier 9 (sampledin 1980)	02NB01AP0012 52NB01AP0012
15	Magaguadavic Lake 1000 m east of Hills Head in center of basin (sampled in 1981)	01NB01AQ0028 51NB01AQ0028
16	St. Croix River at International Bridge, Milltown, Charlotte County, (sampled in 1979 and 1980)	00NB01AR0001
17	St. Croix River, 150 m above bridge, St. Stephen, Charlotte County (sampled in 1979)	52NB01AR0001
18	St. Croix River at confluence of Dennis Stream, Charlotte County (sampled in 1980)	52NB01AR0002
19	Spednic Lake outlet at center opposite confluence of Casey Brook (sampled in 1981)	01NB01AR0016 51NB01AR0016
20	Restigouche River at Rafting Ground Brook (WSC Gauge), Restigouche County (sampled in 1979 and 1980)	00NB01BJ0056
21	Restigouche River (Dalhousie Harbour) 850 m NW of Dalhousie Island Lighthouse, Restigouche County (sampled in 1979 and 1980)	03NB01BJ0001 53NB01BJ0001
22	Nepisiquit River at Nepisiquit Falls Headpond, 300 m above dam (sampled in 1981)	01NB01BK0010 51NB01BK0010
23	Nepisiquit River at Hwy 360	00NB01BK0026

	Bridge near NLU Mine, Gloucester County (sampled in 1979 and 1980)	
24	Nepisiquit River 200 m below old Hwy 11 Bridge, Bathurst, Gloucester County (sampled in 1979)	52NB01BK0002
25	Bathurst Harbour near mouth of Nepisiquit River, Gloucester County (sampled in 1980)	02NB01BK0001 52NB01BK0001
26	Bathurst Harbour, 700 m NNW of Daly Point, Gloucester County (sampled in 1979)	03NB01BL0001 53NB01BL0001
27	Southwest Miramichi River at Hwy Bridge, Blackville, Northumberland County (sampled in 1979 and 1980)	00NB01BO0001
28	Northwest Miramichi River at Wayerton from Hwy 430 Bridge, Northumberland County (sampled in 1979 and 1980)	00NB01BQ0044
29	Miramichi River at Chatham, 750 m below Hwy 11 Bridge, Northumberland County (sampled in 1980)	02NB01BO0001 52NB01BO0001
30	Miramichi River near Loggieville, 1500 m West of St. Andrews Point, Northumberland County (sampled in 1979)	03NB01BO0001
31	Petitcodiac Lake at center, 850 m above Moncton Causeway (under transmission lines) (sampled in 1981)	01NB01BU0001 51NB01BU0001
NOVA SCOTIA		
32	Annapolis River at Hwy Bridge Aylesford, Kings County (sampled in 1981)	00NS01DC0004
33	South River at Hwy Bridge, Millville, Annapolis County (sampled in 1981)	00NS01DC0088
34	Annapolis river above Greenwood at Hwy 201 Bridge, Annapolis County (sampled in 1981)	00NS01DC0089

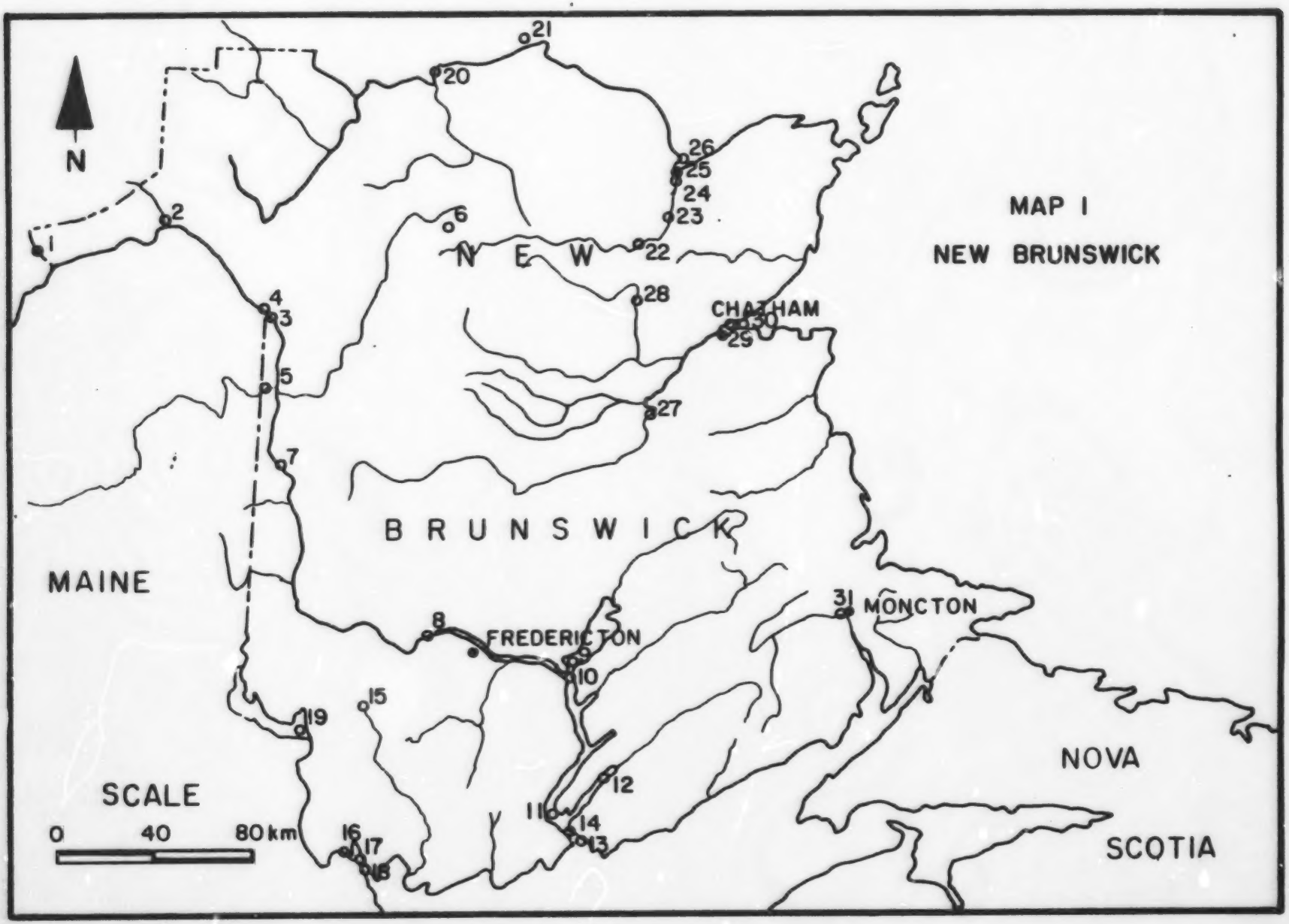
35	Annapolis River at Bridge, 650 m south of Hwy 1 (WSC gauge), Wilmot Station (sampled in 1979, 1980 and 1981)	00NS01DC0001
36	Annapolis River at Bridge, Lawrencetown, Annapolis County (sampled in 1981)	00NS01DC0090
37	Annapolis River Estuary at Hwy 201 Bridge, Bridgetown, Annapolis County (sampled in 1981)	02NS01DC0001 52NS01DC0001
38	Annapolis River near Mochelle at Center (sampled in 1979, 1980 and 1981)	02NS01DC0004 52NS01DC0004
39	Shubenacadie River 400 m above Nine Mile River at Bridge, Elmsdale (sampled in 1979 and 1980)	00NS01DG0008
40	Shubenacadie Lake, 2 km above inlet at Centre, Halifax County (sampled in 1981)	01NS01DG0031 51NS01DG0031
41	Shubenacadie Lake in upper basin 300 m NE of Cochrane Point, Hants County (sampled in 1981)	01NS01DG0032 51NS01DG0032
42	Salmon River at Park Street Extension Bridge, Truro, Colchester County (sampled in 1979)	02NS01DH0002 52NS01DH0002
43	East Brook at Hwy 2 Bridge, Southampton, Cumberland County (sampled in 1980)	00NS01DL0007
44	River Philip at Hwy 204 Bridge, Oxford, Cumberland County (sampled in 1979 and 1980)	00NS01DN0002
45	East River of Pictou at Indian Cross Point 700 m from right bank (sampled in 1981)	02NS01DP0004 52NS01DP0004
46	Pictou Harbour near Town Point Wharf, Pictou County (sampled in 1979)	03NS01DP0001 53NS01DP0001

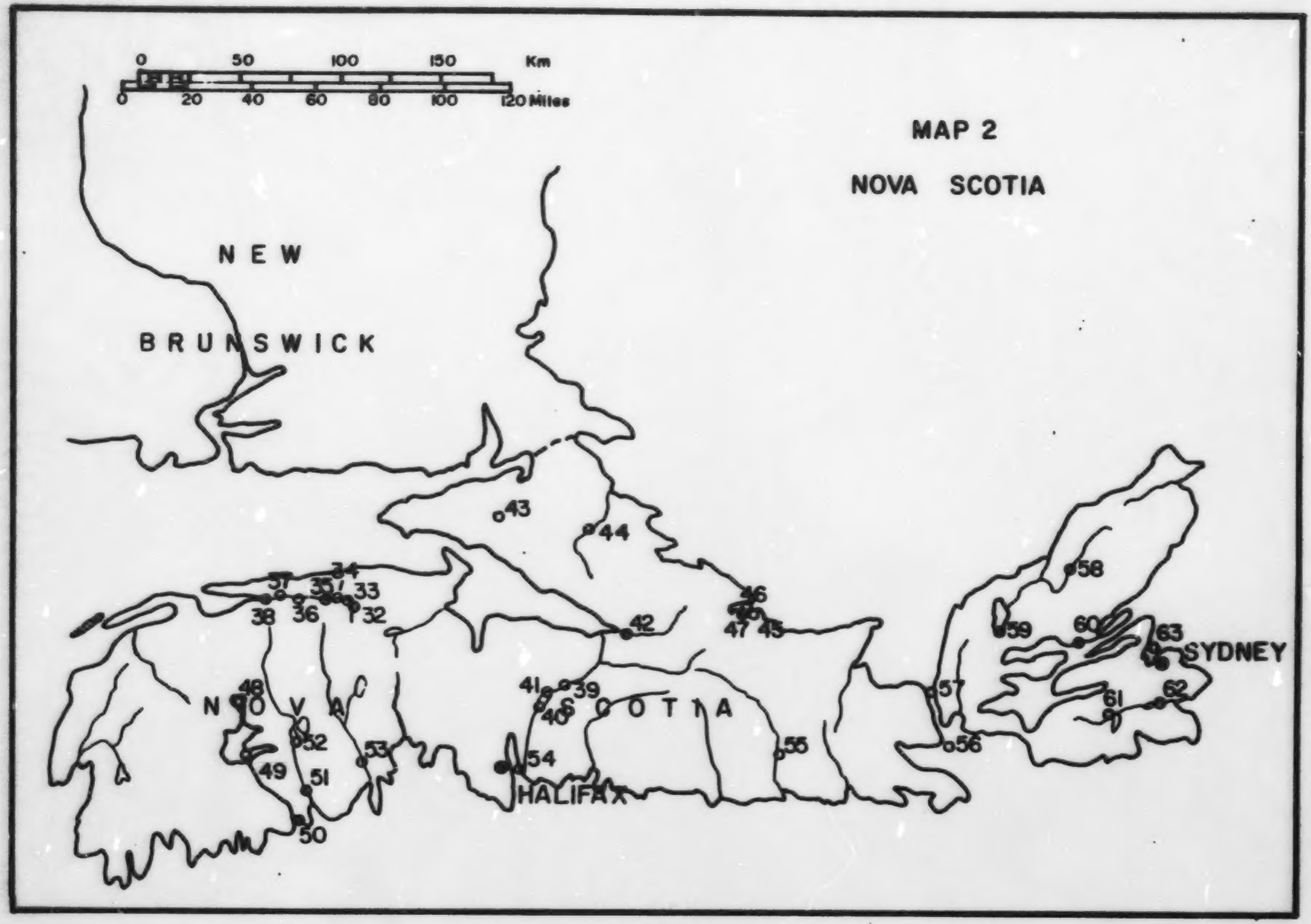
47	Pictou Harbour between jetty and causeway, 200 m from sluice gates (sampled in 1981)	03NS01DP0003 53NS01DP0003
48	Kejimkujik Lake, 500 m NE of Freeman Island, Queens County (sampled in 1981)	01NS01ED0049 51NS01ED0049
49	Lake Rossignol, 650 m above dam at Center, Queens County (sampled in 1981)	01NS01ED0050 51NS01ED0050
50	Liverpool Bay 1 km above Mersey Pulp Mill at Fort Point Shoal Channel Marker, Queens County (sampled in 1980)	03NS01ED0001 53NS01ED0001
51	Medway River at Bridge (WSC Gauge) Charleston, Queens County (sampled in 1979 and 1980)	00NS01EE0001
52	Ponhook Lake at center of outlet 600 m above Round Islands, Queens County (sampled in 1981)	01NS01EE0003 51NS01EE0003
53	Lahave River at Yacht Club near West Lahave, Lunenburg County (sampled in 1980)	03NS01EF0002 53NS01EF0002
54	Halifax Harbour (Eastern Passage) near Shearwater Wharf, Halifax County (sampled in 1979 and 1980)	03NS01EJ0015 53NS01EJ0015
55	St. Mary's River at Bridge (WSC Gauge), Stillwater, Guysborough County, (sampled in 1979 and 1980)	00NS01EO0001
56	Chedabucto Bay, 3 km ESE of Sting Point, Guysborough County (sampled in 1979 and 1980)	03NS01ER0001 53NS01ER0001
57	Strait of Canso at Port Hawkesbury, 650 m West of Public Wharf (sampled in 1981)	03NS01FA0004 53NS01FA0004
58	Northeast Margaree River at Bridge, Margaree Valley (WSC Gauge), Inverness County (sampled in 1979 and 1980)	00NS01FB0001
59	Lake Ainslie, 500 m from southerly tip, Inverness County (sampled	01NS01FB0002 51NS01FB0002

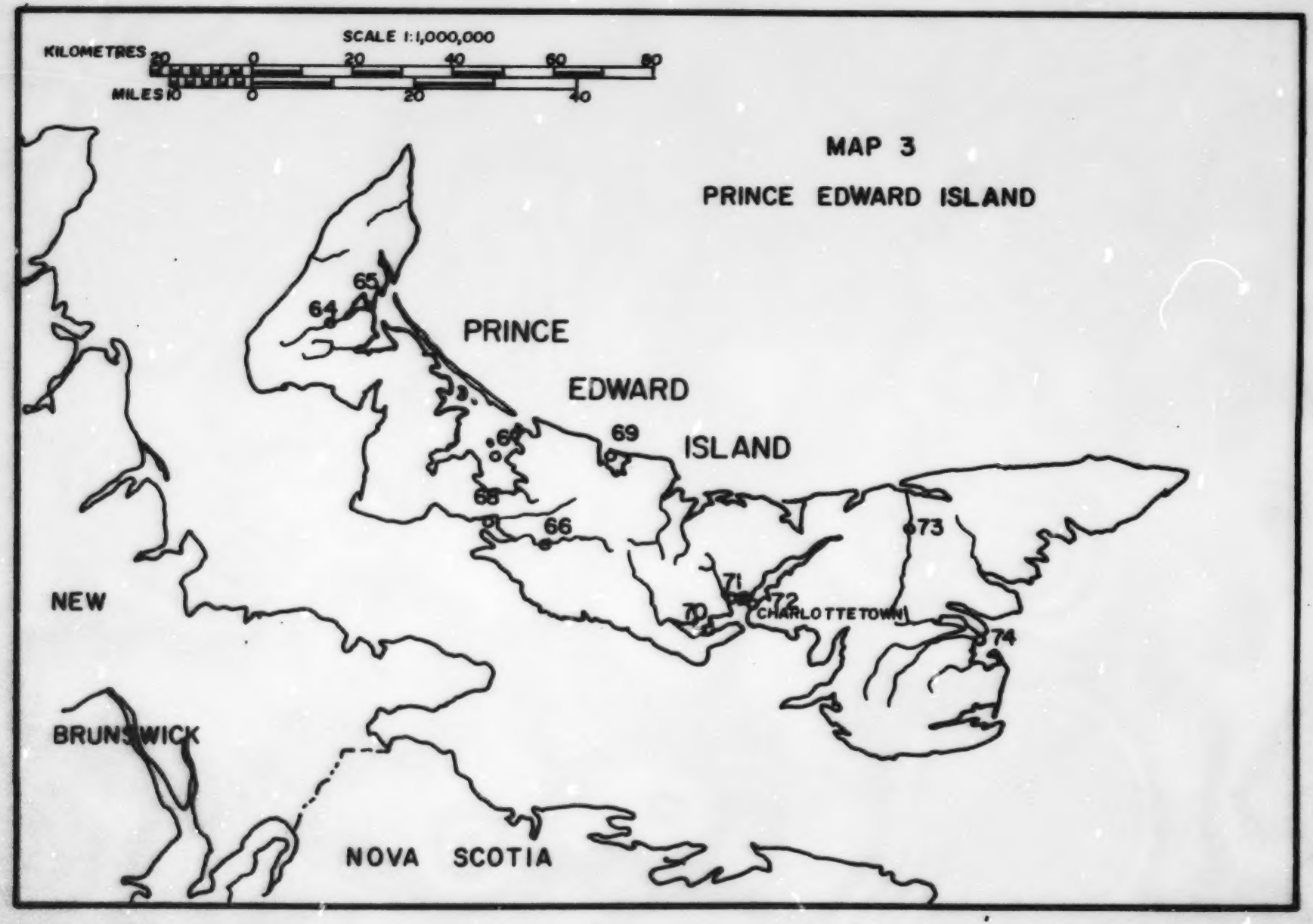
	in 1979 and 1980)	
60	St. Patricks Channel at Baddeck about 200 m SW of Lighthouse on westerly end of Kidston Island (sampled in 1981)	02NS01FP0001 52NS01FP0001
61	Salmon River at Salmon River, Cape Breton County (sampled in 1979 and 1980)	00NS01FJ0001
62	Mira River at Marion Bridge, 500 m below Hwy 327 Bridge at Center, Cape Breton County (sampled in 1981)	00NS01FJ0020 50NS01FJ0020
63	Sydney Harbour 200 m SW of Engineering and Drydock, Cape Breton County (sampled in 1979 and 1980)	03NS01FJ0001 53NS01FJ0001
PRINCE EDWARD ISLAND		
64	Carruthers Brook (Mill River) at WSC Gauge in Bloomfield Park north of St. Anthony, Prince County (sampled in 1979 and 1980)	00PE01CA0001
65	Mill River 1 km below Hwy 12 Bridge at center of Estuaryy, Prince County (sampled in 1981)	02PE01CA0020 52PE01CA0020
66	Dunk River at road Bridge, 5.5 km east of Central Bedeque, Prince County (sampled in 1979 and 1980)	00PE01CB0001
67	Malpeque Bay, 1850 m S61°W from boat launching site at end of Beech Point, Prince County (sampled in 1979 and 1980	03PE01CB0005 53PE01CB0005
68	Summerside Harbour 100 m S25°W from southwestern corner of Queens Wharf, Prince County (sampled in 1979 and 1980)	03PE01CB0006 53PE01CB0006
69	New London Bay, 1200 m East of McEwens Island, Queens County (sampled in 1981)	03PE01CB0007 53PE01CB0007
70	West River at Center of confluence of Ferguson Creek, Queens County	02PE01CC0055 52PE01CC0055

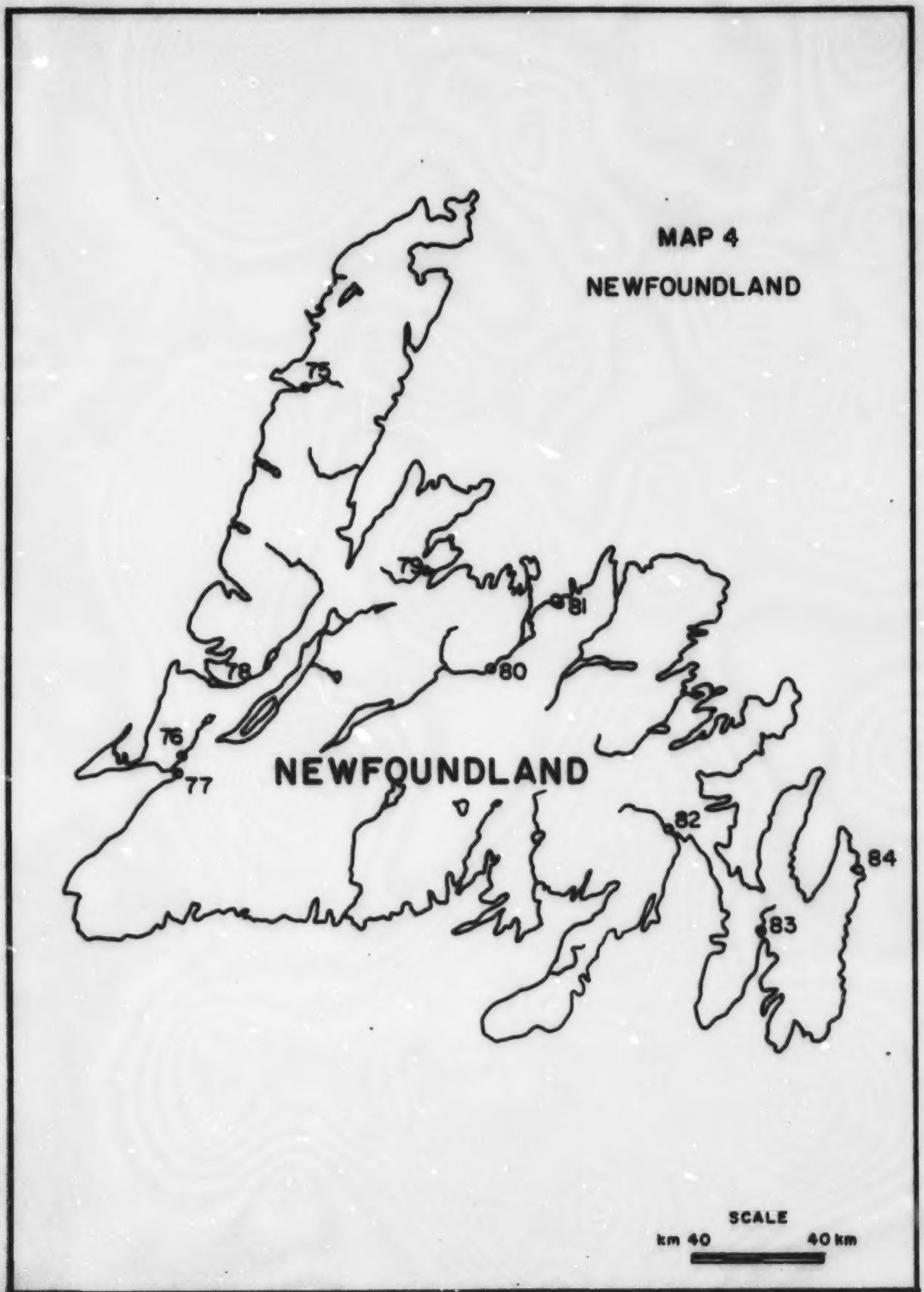
	(sampled in 1981)	
71	North River at Center, 100 m above Cable Crossing, Queens County (sampled in 1981)	02PE01CC0056 52PE01CC0056
72	Charlottetown Harbour, 80 m S65°W from southwestern corner of MOT Marine Terminal, Queens County (sampled in 1979 and 1980)	03PE01CC0005 53PE01CC0005
73	Morell River from road Bridge, 1 km west of Bangor, Kings County (sampled in 1979 and 1980)	00PE01CD0003
74	Georgetown Harbour in Center of Channel between Wightmans Point and Thrumpcap Spit, Kings County (sampled in 1981)	03PE01CB0002 53PE01CB0002
NEWFOUNDLAND		
75	Torrent River at Bristol's Pool, WSC Gauge (sampled in 1980)	00NF02YC0001
76	Harry's River at Black Duck from Hwy Bridge, WSC Gauge (sampled in 1980)	00NF02YJ0001
77	Port Harmon at edge of channel, 600 m SW of Public Wharf (sampled in 1980)	03NF02YJ0001 53NF02YJ0001
78	Humber Arm at Church Cove, 100 m NW of Gulf Oil Pier (sampled in 1980)	03NF02YK0001 53NF02YK0001
79	Indian Brook near Springdale, WSC Gauge (sampled in 1980)	00NF02YM0001
80	Exploits River at Grand Falls (sampled in 1980)	00NF02YO0001
81	Lewisporte Harbour, 100 m West of Main Wharf (sampled in 1980)	03NF02YO0001 53NF02YO0001
82	Pipers Hole River at Mothers Brook (sampled in 1980)	00NF02ZH0001
83	Rocky River at Hwy 6, Colinet (sampled in 1980)	00NF02ZK0001

84	St. John's Harbour, 50 m NNE of SW Corner of Pier 51 (sampled in 1980)	03NF02ZM0001 53NF02ZM0001


N
MAP I
NEW BRUNSWICK
N E W
BRUNSWICK
MAINE
NOVA
SCOTIA
CHATHAM
FREDERICTON
MONCTON
SCALE
0 40 80 km
1
2
3
4
5
6
7
8
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31


0 50 100 150 Km
0 20 40 60 80 100 120 Miles
MAP 2
NOVA SCOTIA
NEW
BRUNSWICK
NOVA SCOTIA
HALIFAX
SYDNEY
31
34
35
33
38
36
32
43
44
42
46
47
45
58
59
60
63
62
61
57
56
41
39
40
48
52
53
54
55
49
51
50


SCALE 1:1,000,000
KILOMETRES 20 0 20 40 60 80
MILES 10 0 20 40
MAP 3
PRINCE EDWARD ISLAND
PRINCE
EDWARD
ISLAND
NEW
BRUNSWICK
NOVA SCOTIA
CHARLOTTETOWN
64
65
67
68
69
66
70
71
72
73
74


MAP 4
NEWFOUNDLAND
NEWFOUNDLAND
75
79
81
78
80
76
77
82
84
83
SCALE
km 40
40 km

APPENDIX II

SOURCES, APPLICATIONS AND PROPERTIES

1.1 CARBOFURAN

Carbofuran (2,3-dihydro-2,2-dimethylbenzofuran-7-benzofuranyl methyl carbamate) is used as an insecticide, acaricide and nematicide, and is one of the major alternatives for the more persistent organochlorine pesticides.

There is a lack of information related to the rates of degradation of this pesticide in the aquatic environment. However, two studies carried out by Bruce (1970) and Charnetski et al. (1977) suggest moderate degradation of the pesticide (4). The information available on sorption of carbofuran by selected soils suggest that only a small fraction of the insecticide will be associated with the sediment. According to the National Research Council of Canada, the investigations of Ladd (1978) and Capps (1978) indicate that carbofuran does not undergo appreciable bioaccumulation. Several studies have verified the extreme toxicity of the chemical to several aquatic organisms at levels in the range of 0.02-1 mg/L (4).

The Atlantic Canada Potato Guide Toxicity Table considers both the granular and suspension formulations of carbofuran as extremely hazardous (5) while the Water Quality Sourcebook (6) considers the

ecological hazards of carbofuran as moderate.

The maximum acceptable limit for domestic water is 100 ug/L with an objective of none detected (6). Livestock Watering Limits is also 100 ug/L (6). Limits are not specified for protection of aquatic life, freshwater or marine.

1.2 CHLORINATED BENZENES

Chlorinated Benzenes are synthetic organic compounds which on the basis of their physical and chemical properties have widespread industrial and agricultural application. These applications include organic intermediates, transformer fluids, pesticides, dyes, lubricants, etc.

Chlorobenzenes are persistent in the aquatic environment, since they are not readily biodegraded, photodegraded or hydrolyzed (11). Chlorinated benzenes have high octanol/water partition coefficients, lipophilic and have low vapor pressure at ambient temperatures, consequently sorption, bioaccumulation and volatilization are expected to be competing processes (11).

The health and ecological effects including the carcinogenic and mutagenic properties of chlorinated benzenes, particularly hexachlorobenzene, are well documented (7,9,23,29). The United States Environmental Protection Agency (EPA) has published guidelines for

hexachlorobenzenes in foodstuffs: poultry meat, fat, shellfree eggs, and dairy products other than cheese are restricted to 0.1 ppm while cheese is set at 0.3 ppm (9).

The EPA has also established criteria for the protection of fresh and salt water life. For fresh water the 24-hour concentration for the following chlorinated isomers are: 1,2-dichlorobenzene - 44 ug/L; 1,3-dichlorobenzene - 310 mg/L; 1,4-dichlorobenzene - 190 ug/L. For salt water these criteria ae 15 ug/L, 22 ug/L and 15 ug/L respectively (9).

1.3 MIREX AND ORGANOCHLORINE PESTICIDES

Mirex (dodecachlorooctahydro-1,3,4-metheno-2H-cyclobuta (c,d)-pentalene) is a synthetic organochlorine compound which is manufactured for use as both a flame retardant (fabrics and plasters) and an insecticide. It is extremely persistent in the environment (8), and highly bioaccumulative. It was first reported in fish in Northern Lake Ontario in 1974. Algae were also found to concentrate Mirex readily. As a stomach poison, Mirex was widely used in Southeast United States to combat fire ants. The use of Mirex was regulated on December 1, 1978.

No limits have been specified for Mirex in water for domestic use, however, for the protection of freshwater and marine aquatic life, a limit of 0.001 mg/L (EPA, 1976) has been established (6).

1.4 PENTACHLOROPHENOL

Pentachlorophenol (PCP), one of a series of chlorinated phenols, is a synthetic compound which is used directly as a pesticide or biocide, or used as intermediates in the manufacture of these products. As a group, chlorinated phenols are used as insecticides, fungicides, mold inhibitors and disinfectants with effectiveness generally increasing as the number of chlorine atoms on the phenol ring increases (10).

The most important use of PCP and its corresponding sodium or potassium salts is for wood preservation. PCP is also used as a fungicide for slime control in pulp and paper manufacture and in a variety of other products such as cutting oils, leather, paint, glue and textiles (12).

Chlorinated phenols are only mildly toxic to terrestrial organisms (10) however human illness and death have occurred from improper handling of PCP-treated lumber and sawdust and from exposure to spray formulations. Its toxicity to fish (TLM) has been reported to be in the range 0.2 to 0.6 mg/L (13).

1.5 PHTHALIC ACID ESTERS

Phthalic acid esters (PAE's) are a family of synthetic organic compounds which are significant with regards to the quantity and range of distribution. The compounds are produced in Canada to the extent of

approximately 23 million kilogram/years (15).

Thirteen PAE's are used in Canada primarily as plasticizers, and appear in a wide variety of plastic products. The major use is in the production of PVC and plastic sheeting, however, they are also used in the production of wire and cable coatings, vinyl upholstery, adhesives, vinyl flooring, footwear, and plastisols. In the United States, some PAE's are being considered for use in electrical capacitors as substitutes for polychlorinated biphenyls (PCB's) (14).

PAE's display reasonably low acute toxicities and current levels of exposure do not seem to pose any immediate threat to the environment or human health. However, it must be emphasized that data regarding environmental levels and pathways and the long term effects of PAE's are far from complete (15).

Phthalic acid esters are listed in Category III of the list of Environment Canada's Priority Chemicals, 1979 (7) which are those substances that may pose a significant danger to human health or the environment and about which further detailed information is required. Residues have been found in air, sediment, water, fish and herring gull eggs.

The International Joint Commission Great Lakes Water Quality Board has recommended maximum levels of 4 ug/L for dibutyl phthalate and 0.6 ug/L for diethylhexyl phthalate. The Board further recommends that until

such time as chronic data on other PAE's becomes available, concentrations of other individual PAE's should be restricted to a recommended quantification level of 0.2 mg/L (15).

1.6 POLYCHLORINATED BIPHENYLS

Polychlorinated Biphenyls (PCB's) are a class of chlorinated organic compounds which are of environmental concern because of their wide dispersal and persistence in the environment. As industrial chemicals they are used as plasticizers and in hydraulic fluids, lubricants, and sealers. Because of the resistance to thermal degradation, they are widely employed in transformers, capacitors and electrical wire.

In the Atlantic Provinces potential inputs of PCB's into coastal and freshwater environments include spillage or dumping of PCB containing fluids (primarily spent transformer and capacitor fluids), addition of treated and untreated municipal and industrial sewage into water systems, leaching from landfill sites and industrial waste disposal sites, vaporization and subsequent local fallout from solid waste disposal sites and long range aerial transport (19).

The combination of low water solubility and high octanol/water partition coefficient (2.8-7.4) indicate polychlorinated biphenyls will have a high affinity for suspended solids, especially those high in organic carbon. This has been confirmed by a number of experiments which

have shown PCB's are quickly absorbed and the greatest amount is usually associated with the sediments or soils in soil-water systems (11). Uptake of PCB's from contaminated sediment may involve both adsorption from direct contact with the sediment particles and water in proximity of the particle, or actual ingestion of sediment particles (21).

1.7 POLYNUCLEAR AROMATIC HYDROCARBONS

Polynuclear aromatic hydrocarbons (PAH's) are homologs of benzene in which three or more aromatic rings are joined in various configurations. The PAH's are a diverse chemical class, and member compounds have been widely distributed in atmospheric particles, freshwater, sediments, soils and leachates.

In general, PAH's are produced by combustion of organic matter under conditions of insufficient amounts of oxygen and/or low combustion temperatures. The environmental sources include natural inputs such as combustion (forest fires), geological phenomena (volcanos, tar pits, etc.), (22) and biological conversion by bacteria and plants, while the major anthropogenic sources are energy production, refuse burning, industrial activity such as coke ovens and coal refuse heaps. Transportation sources account for only about one percent of emitted PAH's on a national inventory basis, however transportation-generated PAH's may approach 50 percent of the urban resident exposures (23).

It has been suggested that PAH's accumulate in the sediment and

biota due to their tendency to absorb strongly on suspended particulates (11). Although they are rapidly bioaccumulated, they are also rapidly metabolized and eliminated from the organism, therefore bioaccumulation especially in vertebrate organisms, is considered to be short-term, and probably unlike the long-term bioaccumulation of more persistent chlorinated organics (11).

Benzo [a] pyrene (BaP) has been linked with the incidence of cancer since 1932 (24), and has been the subject of a variety of toxicological tests (23). Although PAH's have been shown to be strongly carcinogenic, it has never been definitely determined that the levels of PAH found in drinking water are harmful (24). The World Health Organization in Europe recommends that the total concentration of six specific PAH's not exceed 0.002 mg/L for domestic drinking water. The six specific PAH are fluoranthene, benzo [b] fluoranthene, benzo [k] fluoranthene, benzo [a] pyrene, benzo [g,h,i] perylene, and indeno [1,2,3-cd] pyrene. Specific limits have not been set in the United States but the Environmental Protection Agency has recognized several PAH as priority pollutants in water (24).

1.8 TRIARYL PHOSPHATE

Triaryl phosphates are a group of organophosphate compounds used as plasticizers, flame retardants, lubricants and fuel additives. Since they possess good thermal stability and resistance to oxidation, TAP's have been considered as a replacement for polychlorinated biphenyls

(PCB's). Total production in the United States was 44 million kilograms (26) in 1973. Although Canada does not produce TAP's, approximately 1.4 million kilograms are imported each year (15). These large quantities and their diversified usage suggests that these compounds may become widely dispersed throughout the environment. Residues of triphenylphosphate have been identified in fish from several United States rivers and in water from the Great Lakes (27).

Triaryl Phosphates are listed in Category III of the Environment Canada's List of Priority Chemical, 1977 (7) which are defined as those substances which pose a significant danger to human health or the environment and about which further detailed information is required. Toxicity of phosphate esters has been investigated and it was found that the chemicals depressed plasma cholinesterase in fowl, cats, dogs and rats, were neurotoxic to birds and mammals and have caused human poisoning by accidental ingestion (26). Information on the toxicity to aquatic organisms is limited however under chronic exposure conditions, behaviour changes such as impaired swimming and feeding were observed at parts per billion concentrations (27). Exposure of rainbow trout to a mixture of phosphate esters (0.3 - 0.9 mg/L) for 4 months, caused reduced feeding and finally death (26).

No guidelines were recommended for waters for human consumption or protection of marine or aquatic life in the literature reviewed for triaryl phosphates.